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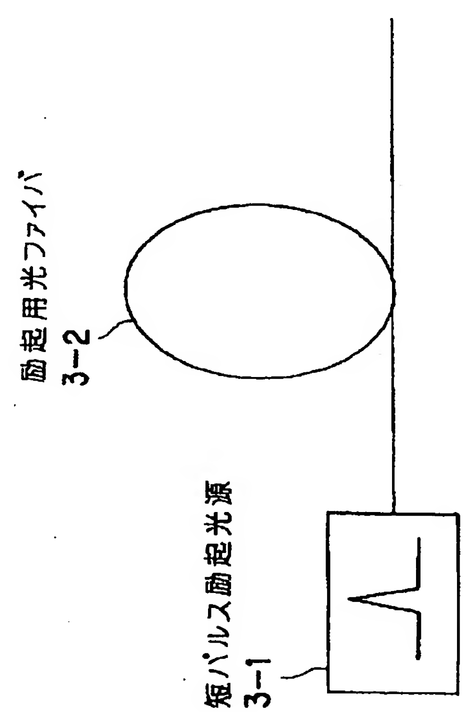
(54)【発明の名称】　波長広帯域短パルス光発生装置

(57)【要約】

【目的】　励起光の固定された中心周波数に対し高低両周波数方向で同調可能な波長広帯域短パルス光発生装置を提供する。

【構成】　短パルス励起光源３－１と励起用光ファイバ３－２とからなり、光ファイバ３－２中のソリトン自己周波数シフトを利用した波長広帯域短パルス光発生装置において、上記短パルス励起光源３－１の出力光波長が上記励起用光ファイバ３－２の零分散波長より０．５ps/nm/km以下だけ大きく設定され、これにより、短パルス特性を維持したまま励起光波長を中心として長短両波長方向に１００ｎｍ以上にわたって連続的に広がるスペクトルを有する出力光を簡単な構成で得られる。



【特許請求の範囲】

【請求項１】 短パルス励起光源と励起用光ファイバとからなり、光ファイバ中のソリトン自己周波数シフトを利用した波長広帯域短パルス光発生装置において、
上記短パルス励起光源の出力光の上記励起用光ファイバ内での分散が0.5ps/nm/km 以下になるように、上記短パルス励起光源の出力光波長を設定したことを特徴とする波長広帯域短パルス光発生装置。

【請求項２】 短パルス励起光源と前記短パルス励起光源を複数に分岐する手段と、各出力光を零分散波長が相異なる複数の励起用光ファイバと、上記複数の励起用光ファイバの出力光を結合して１つの出力とする手段とからなる光ファイバ中のソリトン自己周波数シフトを利用した波長広帯域短パルス発生装置において、
上記短パルス励起光源の出力光が、上記複数の励起用光ファイバうち少なくとも１つの励起用光ファイバ内での分散が0.5ps/nm/km 以下になるように上記短パルス励起光源の出力光波長を設定したことを特徴とする波長広帯域短パルス光発生装置。

【請求項３】 請求項１乃至２記載の波長広帯域短パルス光発生装置の出力光が波長分波手段を通過するようにしたことを特徴とする波長広帯域短パルス光発生装置。

【請求項４】 請求項１，２乃至３項記載の波長広帯域短パルス光発生装置を複数用意し、それらの出力光を結合し、１つの出力としたことを特徴とする波長広帯域短パルス光発生装置。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は光ファイバ、光アンプ等の光学素子の分散特性や利得、損失特性などの光学的諸特性の測定、評価、または光スイッチング装置等に利用される波長広帯域短パルス光発生装置に関するものである。

【０００２】

【従来の技術】発光波長が可変で、かつピコからフェムト秒級の短パルス光の発生方法には、第１の従来例として、広利得幅を有するモード同期色素レーザの共振器の一方のミラーを回折格子に置き換えた構成、または共振器内部に帯域通過光フィルタを挿入した構成を利用した方法がある。しかし、これらの構成はいずれも複雑で面倒な調整を必要とする。また、第２の従来例として、半導体レーザの発振波長の温度依存性を用いて利得スイッチパルス光を発生させる方法も従来より利用されているが、この可変波長幅はたかだか２０ｎｍ程度である。

【０００３】以上の例に加えて、第３の従来例として、ピコ秒台の短パルス光が光ファイバ中で誘起する連続的なスペクトル広がり現象を利用した短パルス光発生法がある。この現象は主に誘導ラマン散乱に伴うソリトン自己周波数シフトにより説明される。ソリトン自己周波数シフトとは、媒質の利得が周波数に対して勾配を持っている場合にソリトンパルスが自身の波形とスペクトルを保とうとして起きる現象で、ソリトンパルスの中心周波数は利得の高い周波数方向に向ってシフトする。M.N.Islam, G.Sucha, I.Bar-Joseph, M.Wegener, J.P.Gordon, and D.S.Chemla,"Broad bandwidths from frequency-shifting solitons in fibers, "OpticsLetters.１４巻，７号，370 〜372 頁，１９８９年に記載されている観測例によれば、波長の連続した短パルス光が長波長方向に数１００ｎｍにわたって得られている。

【０００４】

【発明が解決しようとする課題】しかしながら、実用の観点からは、光素子の評価手段としてしばしば利用されるポンプ・プローブ法やファイバ型光スイッチの分散効果補償のための光源の波長同調等において、励起光の固定された中心周波数に対し高低両周波数方向で同調可能な短パルス光源が必要とされている場合が多い。

【０００５】本発明の目的は、上記の課題に鑑み、励起光の固定された中心周波数に対し高低両周波数方向で同調可能な波長広帯域短パルス光発生装置を提供することにある。

【０００６】

【課題を解決するための手段】上記の課題を解決するために、本発明の請求項１では、短パルス励起光源と励起用光ファイバとからなり、光ファイバ中のソリトン自己周波数シフトを利用した波長広帯域短パルス光発生装置において、上記短パルス励起光源の出力光の上記励起用光ファイバ内での分散が0.5ps/nm/km 以下になるように、上記短パルス励起光源の出力光波長を設定した。また請求項２では、短パルス励起光源と前記短パルス励起光源を複数に分岐する手段と、各出力光を零分散波長が相異なる複数の励起用光ファイバと、上記複数の励起用光ファイバの出力光を結合して１つの出力とする手段とからなる光ファイバ中のソリトン自己周波数シフトを利用した波長広帯域短パルス発生装置において、上記短パルス励起光源の出力光が、上記複数の励起用光ファイバうち少なくとも１つの励起用光ファイバ内での分散が0.5ps/nm/km 以下になるように上記短パルス励起光源の出力光波長を設定した。また請求項３では、請求項１乃至２記載の波長広帯域短パルス光発生装置の出力光が波長分波手段を通過するようにした。また請求項４では、請求項１，２乃至３項記載の波長広帯域短パルス光発生装置を複数用意し、それらの出力光を結合し、１つの出力とした。

【０００７】

【作 用】本発明で利用するソリトン自己周波数シフトに関係する誘導ラマン散乱及び変調不安定による利得スペクトルを図１に示す。１－１は誘導ラマン散乱による利得スペクトル（ラマン利得スペクトル）、１－２は変調不安定による利得スペクトル（変調不安定利得スペクトル）をあらわす。誘導ラマン散乱による利得スペクト

ル１－１が励起光の中心周波数に関し低周波側にのみ現れるのに対して、変調不安定の利得スペクトル１－２は励起光の中心周波数に関し対称に広がる。変調不安定による利得スペクトル１－２の広がり量は励起用光ファイバの群速度分散値Ｄ［ps/nm/km］の平方根に逆比例する。従って、励起光の中心波長と光ファイバの零分散波長をほぼ一致させることにより、より小さな励起光強度で変調不安定の利得を大きく成長させ、ソリトン自己周波数シフトに対する変調不安定の寄与を誘導ラマン散乱に対して大きくし、励起光周波数を中心とした高低両周波数方向へのスペクトル広がりを可能とした。

【０００８】上記第３の従来例で、低周波数方向へのシフトしか起こっていないのは、入射励起光パルスの波長を励起用光ファイバの零分散波長に対し約１００ｎｍ長波長側に設定したため、群速度分散値Ｄが約４ps/nm/kmと大きくなり、変調不安定の利得スペクトルの広がりが抑えられたことによる。

【０００９】本発明では、励起光波長と励起用光ファイバの零分散波長が近いため、短波長側の出力光スペクトルは零分散波長を超えて常分散領域に広がるが、常分散側の短パルス光は励起光パルスの立ち上り部が起こす相互位相変調によってダウンチャープを呈しソリトン性を維持する。異常分散側の短パルス光は自己位相変調によるアップチャープに励起光パルスの立ち下り部が起こす相互位相変調によるアップチャープが加わりソリトン性を維持する。この相互位相変調による誘導ソリトンの原理を図２に示す。２－１は励起光パルス波形、２－２は異常分散領域に現れるソリトン（異常分散側パルス）、２－３は常分散領域に現れるソリトン（常分散側パルス）、２－４は励起光パルスの誘起する相互位相変調周波数シフト量を表す。このため出力光のスペクトルは励起光周波数を中心として高低両周波数方向に短パルス性を維持したまま連続的に広がり、上記出力光を適当な透過帯域を有する帯域通過光フィルタに通すことによりピコからフェムト秒台の短パルス光を得ることができる。

【００１０】

【実施例】本発明の波長広帯域短パルス光発生装置の第１の実施例を図３に示す。３－１は短パルス励起光源、３－２は上記短パルス励起光源３－１からの出力光の分散値が0.5ps/nm/km 以下になるように設定された励起用光ファイバである。短パルス励起光源３－１から出力された短パルス光は光ファイバ３－２を励起し光波長範囲にわたる短パルス光を発生させる。励起用光ファイバ３－２の長さはソリトン圧縮の最適長より十分長いものとする。この構成による実際の発生例のスペクトルを図４に示す。４－１は短パルス励起光（半値全幅４．５ps、中心波長λ_0＝１．３１３９μｍ）のスペクトル、４－２はこれを励起用光ファイバ（零分散波長λ_ZＤ＝１．３０９μｍ、条長４５０ｍ）に通した出力スペクトルである。今回の条件下ではファイバ長を３００ｍ以上にすれば短パルスが発生することが確認されている。図５には上記発生例の時間分解分光像（縦軸：波長、横軸：時間）を示す。５－１、５－２は各々図４の４－１、４－２に対応する短パルス励起光のスペクトル、出力スペクトルである。この例では波長範囲１．２５５～１．３５０μｍにわたって半値全幅数psのパルスが発生する。パルスは全波長範囲に渡り同時に発生するが、波長に応じて遅延時間が異なるため観測点では波長による時間ずれが生じている。

【００１１】この他、波長広帯域短パルス光発生装置は複数個の励起用短パルス光源、励起用光ファイバによって構成することも可能で、この例を図１０、図１１に示す。図１０は共通の励起短パルス光を分散特性の異なる複数の励起用光ファイバに入射することによって発生スペクトルの帯域の拡大を図った構成で、１０－１は励起短パルス光源、１０－２は光分岐器、１０－３は第１の励起用光ファイバ、１０－４は第２の励起用光ファイバ、１０－５は光結合器、１０－６は励起光を除去するための帯域除去フィルタである。励起短パルス光源１０－１からの光の分散が前記複数の励起用光ファイバ１０－３，１０－４のうち少なくとも１本の中で0.5ps/nm/km 以下になるように励起短パルス光源１０－１の出力光波長を設定することにより、該ファイバ中では実施例１と同じスペクトル帯域のパルス光が得られる。その他のファイバ中では励起短パルスの分散値が大きいために誘導ラマン散乱により低周波側にスペクトル帯域を有する短パルス光が得られるので、両者を光結合器１０－５で合波することにより、より広い帯域を有する短パルス光が得られる。また、励起短パルスの分散値が十分に小さくても得られる短パルスの帯域はそれぞれのファイバから得られる帯域の和となるので、励起用ファイバが１本だけのときに比べて広い帯域の短パルス光が得られる。

【００１２】図１１は複数の励起短パルス光と励起用光ファイバの組を用いて発生スペクトルの帯域の拡大を図った構成で、１１－１，１１－２，１１－３は励起短パルス光源、１１－４，１１－５，１１－６は励起用光ファイバ、１１－７，１１－８，１１－９は各励起光を除去するための帯域除去フィルタ、１１－１０は光結合器である。以上の例に示す構成は波長範囲の一層の拡大を可能とする。

【００１３】上記第１の実施例で得られた出力光を利用した波長可変短パルス光源の実施例を図６に示す。これは図３の波長広帯域短パルス光発生装置の出力端に波長可変帯域通過光フィルタ（以下波長可変ＢＰＦと略記）を付加した構成である。６－１は短パルス励起光源、６－２は励起用光ファイバ、６－３は波長可変ＢＰＦである。励起用光ファイバ６－２の出力光は波長可変ＢＰＦ６－３に入射し、所望の波長が切り出される。この様子をスペクトルと時間分解分光像で説明したのが図７である。７－１－１、７－１－２は短パルス励起光源７－１

の出力、７－２－１、７－２－２は励起光ファイバ６－２の出力、７－３－１、７－３－２は波長可変ＢＰＦ６－３の出力の各々スペクトルと時間分解分光像を表わす。波長可変ＢＰＦ６－３の透過バンド中心λｆを励起用光ファイバ６－２の出力光のバンド内で変化させると、この範囲で任意の中心波長λｆを持つ短パルス光が得られる。

【００１４】本方法によれば、励起光波長の周辺で広波長範囲にわたって中心波長の異なるピコからフェムト秒台の短パルスが同時に得られる。これを利用した多波長出力短パルス光源の実施例を図８に示す。８－１は短パルス励起光源、８－２は励起用光ファイバ、８－３－１、８－３－２、８－３－３は帯域通過光フィルタ（以下、ＢＰＦ）、８－４はスターカプラである。励起用光ファイバ８－２の出力光はスターカプラ８－４で複数に分岐され、各々ＢＰＦ８－３－１、８－３－２、８－３－３を通る。この構成によれば互いに異なる波長で、かつ同期した複数の短パルス光が発生可能となる。上記スターカプラとＢＰＦの部分を回折格子やＷＤＭカプラ等の他の分波手段で置き換えた構成も当然可能である。

【００１５】本発明によれば中心波長が広範囲にわたって連続した複数の短パルス群が一挙に得られる。これは光ファイバや光素子の吸収、分散特性の測定用光源として利用可能である。図９(a)(b)に光ファイバの分散測定方法の実施例を示す。図９(a)は測定系を示すもので、９－１は短パルス励起光源、９－２は励起用光ファイバ、９－３は被測定光ファイバである。図９(b)において、９－４－１は励起用光ファイバ９－２の出力光の時間分解分光像で、これを被測定用光ファイバ９－３に通すと、その時間分解分光像は符号９－４－２のように変化し、光ファイバ９－３の群遅延特性を示す。上記光ファイバ９－２の出力光パルスを時間遅延の参照光として、各波長に対する遅延 $t_{out} - t_{in}(\lambda)$ を求めることにより、被測定光ファイバの波長群遅延１／Ｖｇが波長に対し連続的に得られ、その波長微分から波長分散Ｄが求まる。

【００１６】

【発明の効果】以上説明した様に本発明によれば、ソリトン自己周波数シフトを利用した波長広帯域短パルス光発生装置の励起短パルス光の波長が励起用光ファイバの零分散波長よりわずかに大きくなるように設定したので、短パルス特性を維持したまま励起光波長を中心として長短両波長方向に１００ｎｍ以上にわたって連続的に広がるスペクトルを有する出力光を簡単な構成で得られる。従って、波長が異なるピコからフェムト秒級の複数の短パルス光を同時に発生させることが可能となり、波長可変短パルス光源としての用途の他、光ファイバや光素子等の吸収、分散特性の測定用光源として利用できる。

【図面の簡単な説明】

【図１】ソリトン自己周波数シフトに関連する利得スペクトルを示す図

【図２】相互位相変調による誘導ソリトンの原理を示す図

【図３】波長広帯域短パルス光発生装置の実施例を示す図

【図４】波長広帯域短パルス光の発生例（スペクトル）を示す図

【図５】波長広帯域短パルス光の発生例（時間分解分光像）を示す図

【図６】波長可変短パルス光源の実施例を示す図

【図７】図６の動作図

【図８】多波長出力短パルス光源の実施例を示す図

【図９】光ファイバの分散測定方法の実施例を示す図

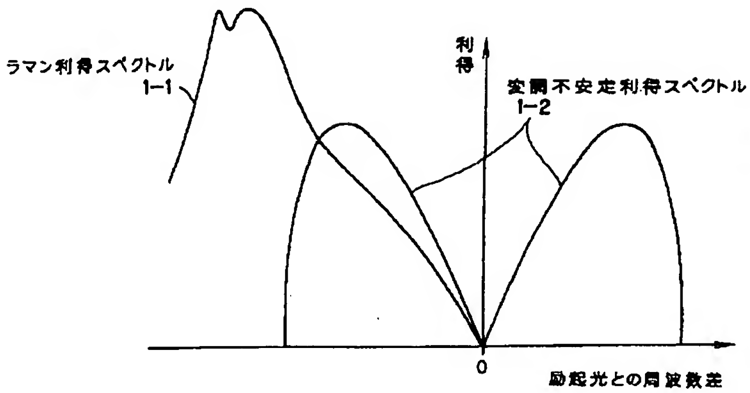
【図１０】白色パルス光源の第２の構成例を示す図

【図１１】白色パルス光源の第３の構成例を示す図

【符号の説明】

１－１…誘導ラマン散乱による利得スペクトル、１－２…変調不安定による利得スペクトル、２－１…励起光パルス波形、２－２…異常分散領域に現れるソリトン、２－３…常分散領域に現れるソリトン、２－４…励起光パルスの誘起する相互位相変調周波数シフト量、３－１…短パルス励起光源、３－２…励起用光ファイバ、４－１…短パルス励起光のスペクトル、４－２…励起用光ファイバの出力スペクトル、５－１…短パルス励起光の時間分解分光像、５－２…励起用光ファイバの出力光の時間分解分光像、６－１…短パルス励起光源、６－２…励起用光ファイバ、６－３…波長可変ＢＰＦ、７－１－１…短パルス励起光源６－１の出力光スペクトル、７－１－２…６－１の出力光の時間分解分光像、７－２－１…励起光ファイバ６－２の出力光スペクトル、７－２－２…６－２の出力光の時間分解分光像、７－３－１…波長可変ＢＰＦ６－３の出力光スペクトル、７－３－２…６－３の出力光の時間分解分光像、８－１…短パルス励起光源、８－２…励起用光ファイバ、８－３－１，８－３－２，８－３－３…ＢＰＦ、８－４…スターカプラ、９－１…短パルス励起光源、９－２…励起用光ファイバ、９－３…被測定光ファイバ、９－４－１…励起用光ファイバ９－２の出力光の時間分解分光像、９－４－２…被測定用光ファイバ９－３の出力光の時間分解分光像、１０－１…励起短パルス光源、１０－２…光分岐器、１０－３，１０－４…励起用光ファイバ、１０－５…光結合器、１０－６…帯域除去フィルタ、１１－１，１１－２，１１－３…励起短パルス光源、１１－４，１１－５，１１－６…励起用光ファイバ、１１－７，１１－８，１１－９…帯域除去フィルタ、１１－１０…光結合器。

【図1】



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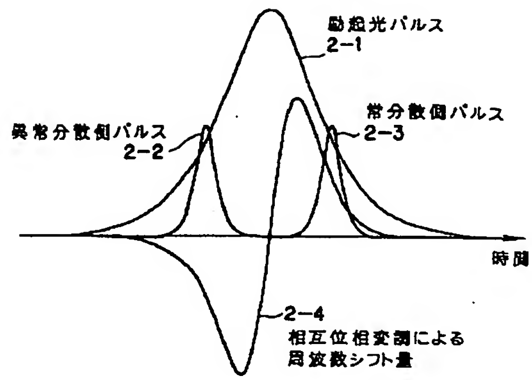

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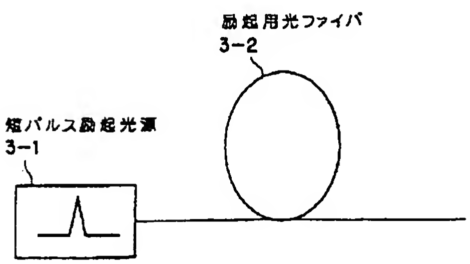

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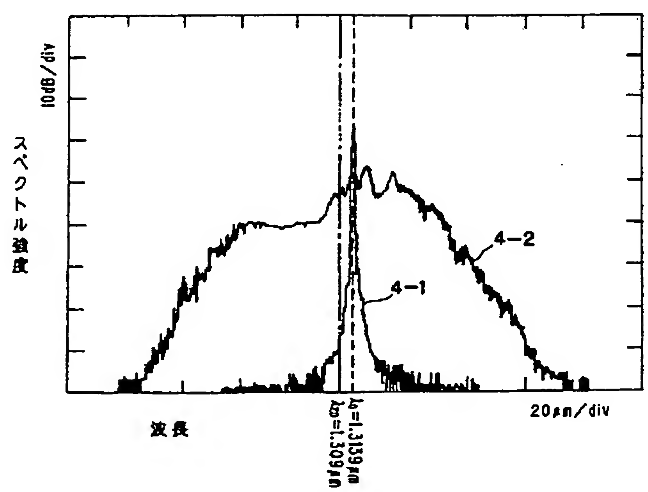

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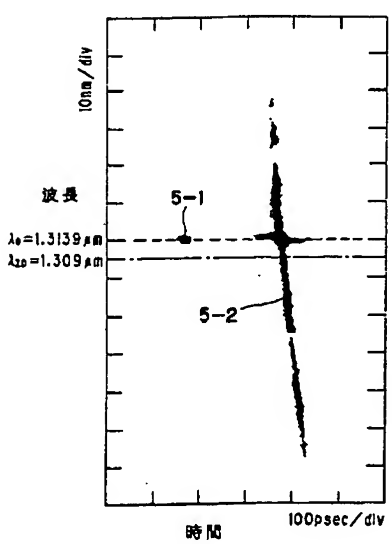

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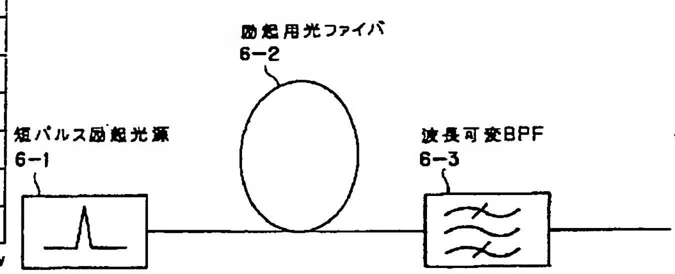
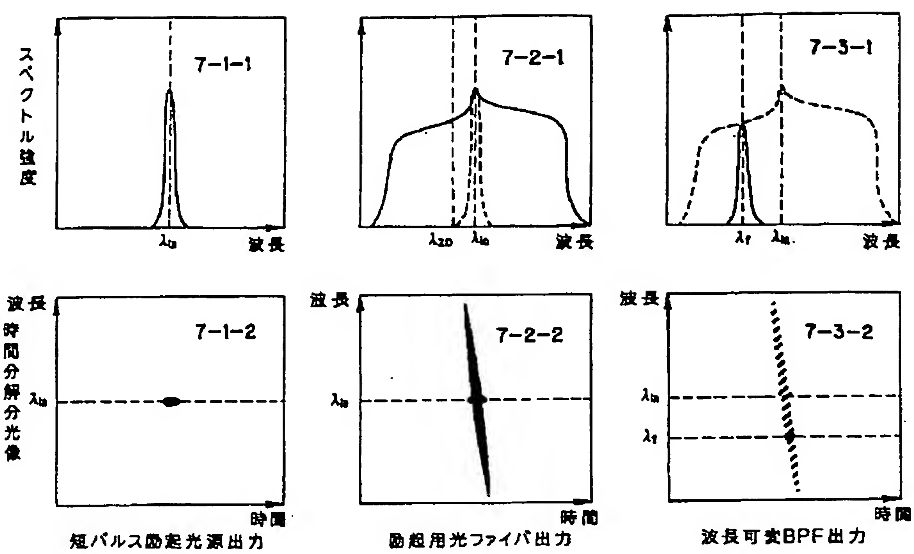
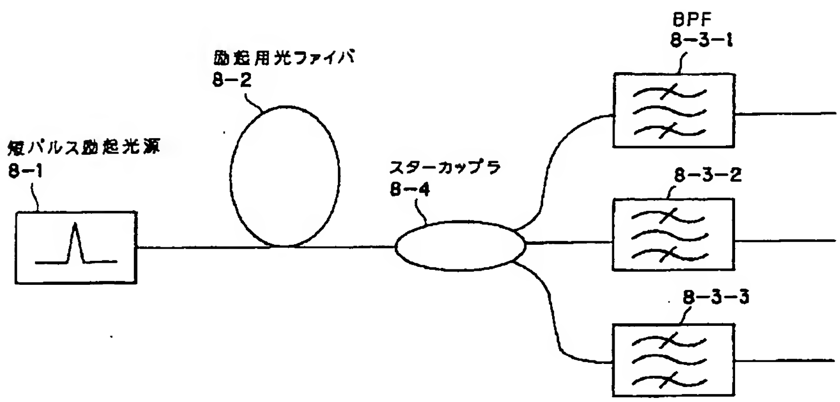


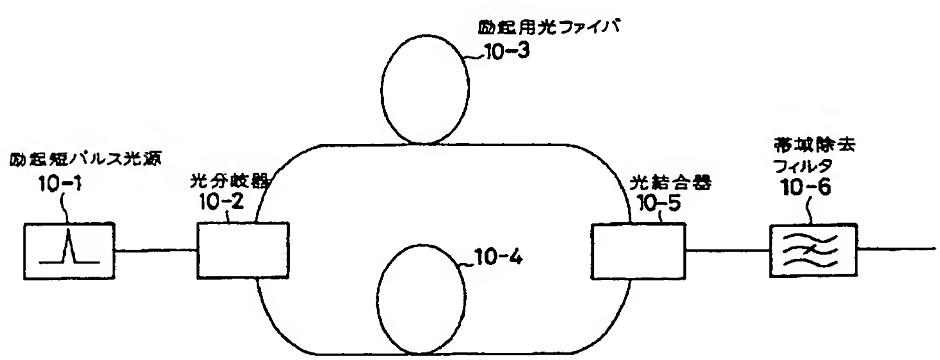
【図7】


スペクトル強度
7-1-1
7-2-1
7-3-1
波長
時間分解分光像
7-1-2
7-2-2
7-3-2
時間
短パルス励起光源出力
励起用光ファイバ出力
波長可変BPF出力

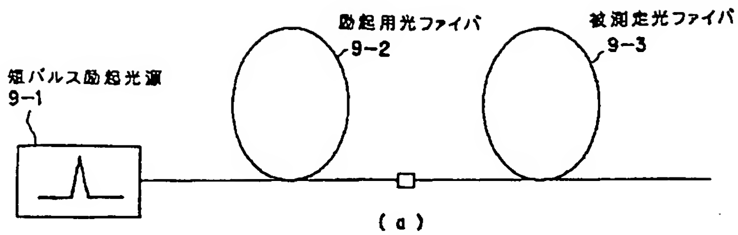
【図8】


BPF
8-3-1
励起用光ファイバ
8-2
短パルス励起光源
8-1
スターカップラ
8-4
8-3-2
8-3-3

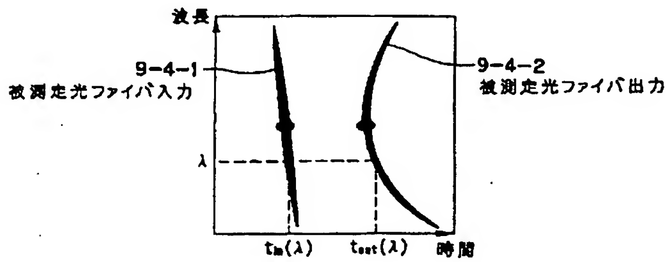
【図10】


励起用光ファイバ
10-3
励起短パルス光源
10-1
光分岐器
10-2
光結合器
10-5
帯域除去
フィルタ
10-6
10-4

【図9】

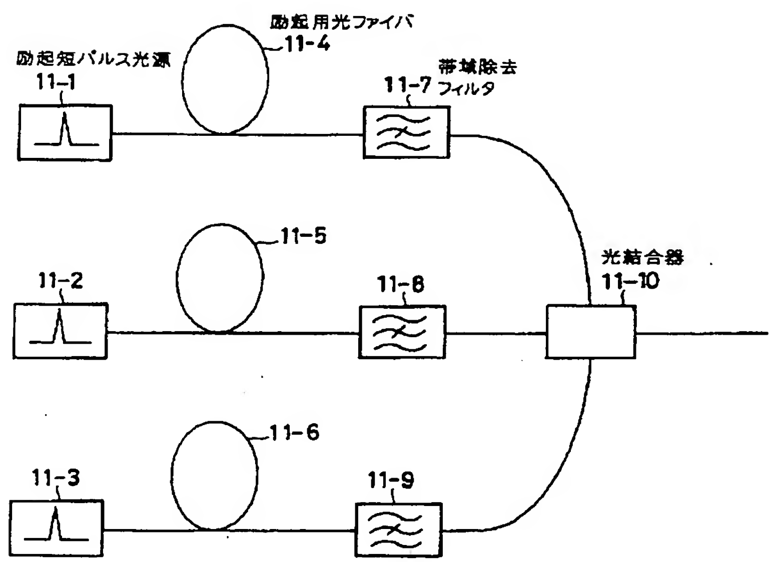

励起用光ファイバ
9-2
被測定光ファイバ
9-3
短パルス励起光源
9-1

(a)


波長
9-4-1
被測定光ファイバ入力
9-4-2
被測定光ファイバ出力
λ
時間

(b)

【図11】


励起用光ファイバ
11-4
励起短パルス光源
11-1
帯域除去
フィルタ
11-7
11-5
11-2
11-8
光結合器
11-10
11-6
11-3
11-9

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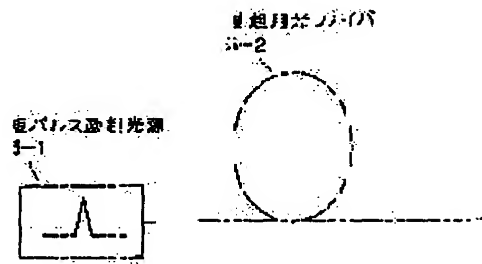
(54) WAVELENGTH WIDE-BAND SHORT PULSE LIGHT GENERATING DEVICE

(57)Abstract:
PURPOSE: To provide the wavelength wide-band short pulse light generating device which can be tuned to the fixed center frequency of exciting light in both high and low frequency directions.
CONSTITUTION: The wavelength wide-band short pulse light generating device consists of a short pulse exciting light source 3-1 and an optical fiber 3-2 for excitation and utilizes a soliton self-frequency shift in the optical fiber 3-2; and the output light wavelength of the short pulse exciting light source 3-1 is set ≤0.5ps/nm/km larger than the zero dispersion wavelength of the optical fiber 3-2 for excitation, and consequently output light which has a spectrum expanding continuously to ≥100nm in both the long and short wavelength directions centering on the exciting light wavelength while short pulse characteristics are maintained is obtained by the simple constitution.



LEGAL STATUS
[Date of request for examination]
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[Date of final disposal for application]
[Patent number]

[Date of registration]
[Number of appeal against examiner's decision of rejection]
[Date of requesting appeal against examiner's decision of rejection]
[Date of extinction of right]

CLAIMS

[Claim(s)]
[Claim 1] It consists of the short pulse excitation light source and an optical fiber for excitation, it sets to the wavelength wide band short pulsed light generator using the soliton self-frequency shift in an optical fiber, and distribution within the above-mentioned optical fiber for excitation of the output light of the above-mentioned short pulse excitation light source is 0.5 ps(es)/nm/km. Wavelength wide band short pulsed light generator characterized by setting up the output light wave length of the above-mentioned short pulse excitation light source so that it may become below.
[Claim 2] A means to branch the short pulse excitation light source and the aforementioned short pulse excitation light source to plurality. Two or more optical fibers for excitation in which zero dispersive-wave length is different from each other in each output light. The means which combines the output light of two or more above-mentioned optical fibers for excitation, and is considered as one output. the wavelength wide band short pulsed light generator equipped with the above -- it is -- the optical fiber for excitation of the above-mentioned plurality [light / output / of the above-mentioned short pulse excitation light source] -- inside -- distribution within at least one optical fiber for excitation -- 0.5 ps(es)/nm/km It is characterized by setting up the output light wave length of the above-mentioned short pulse excitation light source so that it may become below.
[Claim 3] The wavelength wide band short pulsed light generator characterized by making it the output light of a wavelength wide band short pulsed light generator according to claim 1 to 2 pass a wavelength spectral separation means.
[Claim 4] The wavelength wide band short pulsed light generator characterized by having prepared two or more claims 1 and 2 or wavelength wide band short pulsed light generators given in 3 terms, having combined those output light, and considering as one output.

[Translation done.]

* NOTICES *

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] this invention relates to the wavelength wide band short pulsed light generator used for measurement of many optical properties, such as the distributed property of optical elements, such as an optical fiber and optical amplifier, and gain, a loss property, evaluation, or an optical switching device.
[0002]
[Description of the Prior Art] Luminescence wavelength is adjustable and there is a method using the composition which transposed one mirror of the resonator of the mode locking dye laser which has extensive gain width of face to the diffraction grating, or the composition which inserted the band-pass light filter in the interior of a resonator among the generating methods of the short pulsed light of the FEMUTO second class as 1st conventional example from the pico. However, each of these composition needs complicated and troublesome adjustment. Moreover, although the method of generating gain switch pulsed light, using the temperature dependence of the oscillation wavelength of semiconductor laser as 2nd conventional example is also used conventionally, this adjustable wavelength width of face is at most about 20nm.
[0003] In addition to the above example, there is short pulsed light evolution method which used the continuous spectrum breadth phenomenon in which the short pulsed light of a picosecond base carries out induction in an optical fiber as 3rd conventional example. This phenomenon is mainly explained by the soliton self-frequency shift accompanying stimulated Raman scattering. A soliton self-frequency shift is the phenomenon of a soliton pulse maintaining an own wave and an own spectrum, and occurring, when the gain of a medium has inclination to frequency, and the center frequency of a soliton pulse is shifted toward the high frequency direction of gain. M.N. Islam, G.Sucha, I.Bar-Joseph, M.Wegener, J.P.Gordon, and D.S.Chemla, "Broad bandwidths from frequency-shifting solitons in fibers, "OpticsLetters.14 volume, No. 7, and 370-372 According to the page and the example of observation indicated in 1989, the short pulsed light which wavelength followed is obtained over several 100nm in the long wavelength direction.
[0004]
[Problem(s) to be Solved by the Invention] However, from a viewpoint of practical use, the source of short pulsed light which can align in height both the frequency direction is needed in many cases to the center frequency to which excitation light was fixed in the pump probe method often used as a light-corpuscle child's evaluation means, wavelength alignment of the light source for dispersion effect compensation of a fiber type optical switch, etc.
[0005] The purpose of this invention is to offer the wavelength wide band short pulsed light generator which can be aligned in height both the frequency direction in view of the above-mentioned technical problem to the center frequency to which excitation light was fixed.
[0006]
[Means for Solving the Problem] In order to solve the above-mentioned technical problem, in the claim 1 of this invention, it consists of the short pulse excitation light source and an optical fiber for excitation, and sets to the wavelength wide band short pulsed light generator using the soliton self-frequency shift in an optical fiber, and distribution within the above-mentioned

optical fiber for excitation of the output light of the above-mentioned short pulse excitation light source is 0.5 ps(es)/nm/km. The output light wave length of the above-mentioned short pulse excitation light source was set up so that it might become below. Moreover, a means to branch the short pulse excitation light source and the aforementioned short pulse excitation light source to plurality in a claim 2, In the wavelength wide band short pulse generator using th soliton self-frequency shift in the optical fiber which consists of a means which combines the output light of two or more optical fibers for excitation in which zero dispersive-wave length is different from each other in each output light, and two or more above-mentioned optical fibers for excitation, and is considered as one output the optical fiber for excitation of the above-mentioned plurality [light / output / of the above-mentioned short pulse excitation light source] -- inside -- distribution within at least one optical fiber for excitation -- 0.5 ps(es)/nm/km The output light wave length of the above-mentioned short pulse excitation light source was set up so that it might become below. Moreover, it was made for the output light of a wavelength wide band short pulsed light generator according to claim 1 to 2 to pass a wavelength spectral separation means in a claim 3. Moreover, in the claim 4, two or more claims 1 and 2 or wavelength wide band short pulsed light generators given in 3 terms were prepared, those output light was combined, and it considered as one output.

[0007]

[For **] The gain spectrum by the stimulated Raman scattering related to the soliton self-frequency shift used by this invention and modulation instability is shown in drawing 1 . The gain spectrum (Raman gain spectrum) according [1-1] to stimulated Raman scattering and 1-2 express the gain spectrum (modulation unstable gain spectrum) by modulation instability. The gain spectrum 1-2 of modulation instability spreads symmetrically about the center frequency of excitation light to the gain spectrum 1-1 by stimulated Raman scattering appearing only in a low frequency side about the center frequency of excitation light. The amount of breadths of the gain spectrum 1-2 by modulation instability is inversely proportional to the square root of group-velocity distribution value [of the optical fiber for excitation] D [ps/nm/km]. Therefore, by carrying out simultaneously coincidence of the main wavelength of excitation light, and the zero dispersive-wave length of an optical fiber, the gain of modulation instability was greatly grown up by smaller excitation light intensity, contribution of modulation instability to a soliton self-frequency shift was enlarged to stimulated Raman scattering, and the spectrum breadth to height both the frequency direction centering on excitation optical frequency was made possible.

[0008] in the conventional example of the above 3rd, only the shift in the direction of low frequency has taken place -- the wavelength of an incidence excitation optical pulse -- the zero dispersive-wave length of the optical fiber for excitation -- receiving -- about 100nm -- a long wave -- since it set to the merit side -- the group-velocity distribution value D -- about 4 -- ps/nm/km -- large -- becoming -- a modulation -- it is because the breadth of an unstable gain spectrum was stopped

[0009] Since excitation light wave length and the zero dispersive-wave length of the optical fiber for excitation are near, although the output light spectrum by the side of short wavelength spreads to a normal dispersion field in this invention exceeding zero dispersive-wave length, by the mutual phase modulation which an excitation optical pulse starts and the section causes, the short pulsed light by the side of normal dispersion presents a down chirp, and maintains soliton nature. The rise chirp by the mutual phase modulation which the falling section of an excitation optical pulse causes to the rise chirp by self-phase modulation is added, and the short pulsed light by the side of anomalous dispersion maintains soliton nature. The principle of the guidanc soliton by this mutual phase modulation is shown in drawing 2 . The soliton (anomalous-dispersion side pulse) to which 2-1 appears in an excitation optical pulse wave, and 2-2 appears in an anomalous-dispersion field, the soliton (normal dispersion sid pulse) to which 2-3 app ars in a normal dispersion field, and 2-4 express the mutual phase modulation frequency shift amount in which an excitation optical pulse carries out induction. For this r ason, the spectrum of output light spreads continuously, maintaining short pulse nature in height both the frequency direction focusing on excitation optical frequency, and can obtain the short pulsed light of FEMUTO **** from the pico by letting the above-mentioned output light pass in the band-pass

light filter which has a suitable transparency band.
[0010]
[Example] The 1st example of the wavelength wide band short pulsed light generator of this invention is shown in drawing 3 . For the short pulse xcitation light source and 3-2, the distributed value of the output light from the above-mentioned short pulse excitation light source 3-1 is [3-1] 0.5 ps(es)/nm/km. It is the optical fiber for excitation set up so that it might become below. The short pulsed light outputted from the short pulse excitation light source 3-1 excites an optical fiber 3-2, and generates the short pulsed light covering the light wave length range. Let the length of the optical fiber 3-2 for excitation be a thing sufficiently longer than th optimal length of soliton compression. The spectrum of the actual example of generating by this composition is shown in drawing 4 . It is the output spectrum to which 4-1 let this with the spectrum of short pulse excitation light (full-width-at-half-maximum 4.5ps, main wavelength lambda0=1.3139micrometer), and 4-2 let it pass to the optical fiber for excitation (zero dispersive-wave length lambdaZD=1.309micrometer, 450m of ** length). Under these conditions, if fiber length is set to 300m or more, it is checked that a short pulse occurs. The time decomposition part light figure (vertical axis : wavelength, a horizontal axis : time) of the above-mentioned example of generating is shown in drawing 5 . 5-1 and 5-2 are 4-1 of drawing 4 , the spectrum of the short pulse excitation light corresponding to 4-2, and an output spectrum respectively. In this example, the pulse of the number ps of full width at half maximum occurs over the wavelength range of 1.255-1.350 micrometers. Although a pulse is simultaneously generated over the full wave length range, since time delays differ according to wavelength, the time gap by wavelength has arisen in the station.
[0011] In addition, a wavelength wide band short pulsed light generator is possible also for constituting by two or more sources for excitation of short pulsed light, and the optical fiber for excitation, and shows this example to drawing 10 and drawing 11 . Drawing 10 is the composition of having aimed at expansion of the band of a generating spectrum by carrying out incidence of the common excitation short pulsed light to two or more optical fibers for excitation from which a distributed property differs, and 10-1 is a band reject filter for in an optical turnout and 10-3, the 2nd optical fiber for excitation and 10-5 removing an optical coupling machine, and the 1st optical fiber for excitation and 10-4 removing [the source of excitation short pulsed light, and 10-2] excitation light, as for 10-6. Distribution of the light from the source 10-1 of excitation short pulsed light is [two or more aforementioned optical fibers 10-3 for excitation, and] 0.5 ps (es)/nm/km in at least one among 10-4. By setting up the output light wave length of the source 10-1 of excitation short pulsed light so that it may become below, the pulsed light of the same spectrum-band region as an example 1 is obtained in this fiber. In other fibers, since the distributed value of an excitation short pulse is large and the short pulsed light which has a spectrum-band region in a low frequency side by stimulated Raman scattering is obtained, the short pulsed light which has a wide band more is obtained by multiplexing both with the optical coupling vessel 10-5. Moreover, since the band of the short pulse acquired even if the distributed value of an excitation short pulse is fully small serves as the sum of the band obtained from each fiber, compared with the time only of one, the short pulsed light of a wide band is obtained for the fiber for excitation.
[0012] Drawing 11 is the composition of having aimed at expansion of the band of a generating spectrum using two or more excitation short pulsed light and the group of the optical fiber for excitation, and the band reject filter for the optical fiber for excitation, 11-7, 11-8, and 11-9 removing [11-1, 11-2, and 11-3] each excitation light in the source of excitation short pulsed light, 11-4, 11-5, and 11-6 and 11-10 are optical coupling machines. The composition shown in the above example enables much more expansion of the wavelength range.
[0013] The example of the source of wavelength adjustable short pulsed light using the output light obtained in the 1st example of the above is shown in drawing 6 . This is the composition which added the wavelength variable-bandpass light filter (it is written as wavelength adjustable BPF below) to the outgoing end of the wavelength wide band short pulsed light generator of drawing 3 . 6-1 -- the short pulse excitation light source and 6-2 -- the optical fiber for excitation, and 6-3 -- the wavelength adjustable -- it is BPF Incidence of the output light of the

optical fiber 6-2 for excitation is carried out to wavelength adjustable BPF6-3, and desired wavelength is started. Drawing 7 explained this situation according to the spectrum and th time decomposition part light figure. 7-1-1 and 7-1-2 -- the output of the short puls excitation light source 7-1, 7-2-1, and 7-2-2 -- the output of the excitation optical fiber 6-2, and 7-3 -1 and 7-3-2 express the each spectrum of the output of wavelength adjustabl BPF6-3, and a tim decomposition part light figure If transparency band center lambdaf of wavelength adjustable BPF 6-3 is changed within the band of the output light of the optical fiber 6-2 for excitation, the short pulsed light which has arbitrary main wavelength lambdaf in this range will be obtained.
[0014] According to this method, the short pulse of FEMUTO **** is simultaneously acquired from the pico from which main wavelength differs over the extensive wavelength range around excitation light wave length. The example of the source of multi-wavelength output short pulsed light using this is shown in drawing 8 . For 8-1, as for the optical fiber for excitation, 8-3-1, 8-3-2, and 8-3-3, the short pulse excitation light source and 8-2 are [a band-pass light filter (following, BPF) and 8-4] star couplers. The output light of the optical fiber 8-2 for excitation branches to plurality by the star coupler 8-4, and passes along BPF 8-3-1, 8-3-2, and 8-3-3 respectively. Generating of two or more short pulsed light which is mutually different wavelength according to this composition, and synchronized is attained. Naturally the composition which replaced the portions of the above-mentioned star coupler and BPF with other spectral separation meanses, such as a diffraction grating and a WDM coupler, is also possible.
[0015] According to this invention, two or more short pulse groups which main wavelength reached far and wide and followed are obtained at once. This can be used as absorption of an optical fiber or a light-corpuscle child, and the light source for measurement of a distributed property. The example of the distributed measuring method of an optical fiber is shown in drawing 9 (a) and (b). Drawing 9 (a) System of measurement is shown and, as for the short pulse excitation light source and 9-2, 9-1 is [the optical fiber for excitation and 9-3] measuring beam-ed fibers. Drawing 9 (b) It sets, and 9-4-1 is the time decomposition part light figure of the output light of the optical fiber 9-2 for excitation, and when it lets this pass to the optical fiber 9-3 for [measured], the time decomposition part light figure changes like a sign 9-4-2, and shows the group delay frequency characteristics of an optical fiber 9-3. By calculating delay tout-tin [as opposed to each wavelength for the output optical pulse of the above-mentioned optical fiber 9-2] (lambda) as a reference beam of a time delay, the wavelength group delay 1 of a measuring beam-ed fiber/Vg is continuously obtained to wavelength, and a wavelength dispersion D can be found from the wavelength differential.
[0016]
[Effect of the Invention] The output light which has the spectrum which spreads continuously over 100nm or more in merits-and-demerits both the wavelength direction focusing on excitation light wave length, maintaining short pulse characteristics since it set up according to this invention so that the wavelength of the excitation short pulsed light using the soliton self-frequency shift of a wavelength wide band short pulsed light generator might become large slightly from the zero dispersive-wave length of the optical fiber for excitation as explained above is obtained with easy composition. Therefore, it becomes possible to generate simultaneously two or more short pulsed light of the FEMUTO second class from the pico from which wavelength differs, and can use as absorption of an others, an optical fiber, a light-corpuscle child, etc., and the light source for measurement of a distributed property. [use / as a source of wavelength adjustable short pulsed light]

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] Drawing showing the gain spectrum relevant to a soliton self-frequency shift
[Drawing 2] Drawing showing the principle of the guidance soliton by the mutual phase modulation
[Drawing 3] Drawing showing the example of a wavelength wide band short pulsed light generator

[Drawing 4] Drawing showing the example of generating of wavelength wide band short pulsed light (spectrum)
[Drawing 5] Drawing showing the example of generating of wavelength wide band short pulsed light (time decomposition part light figure)
[Drawing 6] Drawing showing the example of the source of wavelength adjustable short pulsed light
[Drawing 7] The cyclegraph of drawing 6
[Drawing 8] Drawing showing the example of the source of multi-wavelength output short pulsed light
[Drawing 9] Drawing showing the example of the distributed measuring method of an optical fiber
[Drawing 10] Drawing showing the 2nd example of composition of the source of white pulsed light

[Drawing 11] Drawing showing the 3rd example of composition of the source of white pulsed light

[Description of Notations]
1-1 -- The gain spectrum by stimulated Raman scattering, 1-2 -- The gain spectrum by modulation instability, 2-1 -- An excitation optical pulse wave, 2-2 -- The soliton which appears in an anomalous-dispersion field, 2-3 -- The soliton, 2-4 which appear in a normal dispersion field -- The mutual phase modulation frequency shift amount in which an excitation optical pulse carries out induction, 3-1 [-- The spectrum of short pulse excitation light,] -- The short pulse excitation light source, 3-2 -- The optical fiber for excitation, 4-1 4-2 -- The output spectrum of the optical fiber for excitation, 5-1 -- The time decomposition part light figure of short pulse excitation light, 5-2 -- The time decomposition part light figure of the output light of the optical fiber for excitation, 6-1 -- Short pulse excitation light source, 6-2 [-- The output light spectrum of the short pulse excitation light source 6-1,] -- The optical fiber for excitation, 6-3 -- Wavelength adjustable BPF, 7-1-1 The time decomposition part light figure of the output light of 7-1-2--6-1, 7-2-1 -- The output light spectrum of the excitation optical fiber 6-2, The time decomposition part light figure of the output light of 7-2-2--6-2, 7-3-1 -- The output light spectrum of wavelength adjustable BPF 6-3, The time decomposition part light figure of the output light of 7-3-2--6-3, 8-1 -- Short pulse excitation light source, 8-2 -- The optical fiber for excitation, 8-3-1, 8-3-2, 8-3-3 -- BPF, 8-4 [-- The optical fiber for excitation,] -- A star coupler, 9-1 -- The short pulse excitation light source, 9-2 9-3 -- A measuring b am-ed fiber, 9-4-1 -- The time decomposition part light figure of the output light of the optical fiber 9-2 for excitation, 9-4-2 -- The time decomposition part light figure of the output light of the optical fiber 9-3 for [measured], 10-1 [-- The optical fiber for excitation,] -- The source of

excitation short pulsed light, 10-2 -- An optical turnout, 10-3, 10-4 10-5 [-- The source of excitation short pulsed light, 11-4, 11-5 11-6 / -- The optical fiber for excitation, 11-7, 11-8, 11-9 / -- A band reject filter, 11-10 / -- Optical coupling machine.] -- An optical coupling machine, 10-6 -- A band reject filter, 11-1, 11-2, 11-3

[Translation done.]